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**RECEIVER**

(Jushin-ki)

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## SPECIFICATION

Title of the Invention

Receiver

### Claims

A receiver, which is characterized by the fact that when a first broadcast wave is received from a composite signal containing a second broadcast wave and a third broadcast wave adjacent thereto with the first broadcast wave to be received as center,

the above composite signal is frequency-converted so that the carrier frequency of the above first broadcast wave becomes a first frequency and the above composite signal is frequency-converted so that the above carrier frequency becomes a second and a third frequencies just as the above composite signal distributes in both-side bands with the first frequency as center,

the conversion frequencies are so selected as to relatively deviate by only twice as much as an interoffice frequency to the above first frequency, and only the above first broadcast wave

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<sup>1</sup> Numbers in margin indicate pagination in foreign text.

is obtained by synthesizing these frequency-converted composite signals.

#### Detailed Description of the Invention

For example, when channels adjacent to a receiving channel exist in AM broadcast, they become a frequency spectrum relation as shown in Fig. 1. Namely, when a second and a third broadcast waves  $S_A$ ,  $S_C$  exist on both side of a broadcast wave to be received (called the first broadcast wave)  $S_B$ , they have occupied zones  $\gamma$  ( $\gamma = 7.5 \text{ Hz}$ ) of side wave band components, therefore the side wave band components superimpose as illustrated, accordingly, if an adjacent channel is a large electric power station, a so-called adjacent-channel disturbance occurs.

The present invention proposes a receiver which can surely eliminate such an adjacent-channel disturbance. The receiver based on the present invention will be illustrated in detail by reference to drawings below and is a case suited to an AM receiver in this example.

In Fig. 2, 1 is a high-frequency amplifier, 2 is a medium-frequency amplifier, 3 is a synchronous detector consisting of i. e., a multiplizer and gives an AM detector output to a terminal 4.

In the present invention, when a first broadcast wave  $S_B$  is received from a composite signal  $S_0$  containing a second broadcast wave and a third broadcast wave  $S_A$ ,  $S_C$  adjacent thereto with the first broadcast wave to be received  $S_B$  as center,

the above composite signal is frequency-converted so that the car-

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rier frequency  $f_b$  of the above first broadcast wave  $S_B$  becomes a first frequency, e. g., a medium-frequency  $f_i$ , and the above composite signal  $S_0$  is frequency-converted so that the above carrier frequency  $f_b$  becomes a second and a third frequencies  $f_a$ ,  $f_c$  just as the above composite signal  $S_0$  distributes in both-side bands with the first frequency  $f_i$  as center,

the conversion frequencies are so selected as to relatively deviate by twice as much as an interoffice frequency  $I$  to the above first frequency  $f_i$ . Then, these frequency-converted composite signals  $S_{OM}$ ,  $S_{OL}$ ,  $S_{OH}$  are synthesized, consequently, the phases of said converted composite signals  $S_{OM}$ ,  $S_{OL}$ ,  $S_{OH}$  are selected so that only the first broadcast wave can be received among them.

The first to third frequency converters **10M**, **10L** and **10H** are provided to obtain these converted composite signals in the present invention. Their constitutions is illustrated in due order while seeing Fig. 3, and the first frequency converter **10M**

is provided to obtain the first converted composite signal  $S_{OM}$  as shown in Fig. 3A.

This converter 10M is constructed by one mixer, and an output  $S_1$  obtained by a local oscillator 5 is fed with the broadcast wave  $S_B$  to be received. In this case, the output of said high-frequency amplifier 1 is not a single broadcast wave in the presence of adjacent channels and contains the second and the third broadcast wave beginning with the first broadcast wave  $S_B$ . Namely, it is a composite signal  $S_0$ , but only the first broadcast wave  $S_B$  is shown for the convenience in the drawing. If such a signal is fed to the converter 10M and the carrier frequency  $f_b$  in the first broadcast wave to be received  $S_B$  is converted to the first frequency, as shown in Fig. 3A, the entire composite signal  $S_0$  is frequency-converted to this converted composite signal  $S_{OM}$ . In this example, the first frequency is selected as the medium frequency  $f_b$ . Therefore, the first converted composite signal  $S_{OM}$  is taken as the first medium-frequency signal.

Moreover, this Fig. 3 only shows carriers in respective broadcast waves. Then, the horizontal axis is shown by the angular frequency  $\omega$  for convenience. Therefore,  $\omega_a - \omega_c$  are taken as angular frequencies of carriers in the first - third broadcast wave  $S_A - S_0$ , and  $\omega_i$  is taken as an angular frequency

relating to the medium frequency  $f_1$ . Then,  $\omega$  corresponds to an angular frequency of an interoffice frequency  $f_w$  (10 kHz).

In the present invention, the second and third frequency converters 10L and 10H are thus provided to form the second and third conversion frequencies  $S_{OL}$ ,  $S_{OH}$  as the first conversion frequency  $S_{OM}$  is formed. In this case, as shown in Fig. 3, the frequency conversion is so conducted that the angular frequency  $\omega_b$  of carrier in the first broadcast wave  $S_B$  only deviates by  $2\omega$  in the relation among the three. It is illustrated from the second frequency converter 10L.

The second frequency converter 10L is constructed by the first and the second mixers 11A, 11B, and a signal made into a frequency relationship as described below is fed to the first mixer 11A. Namely, a first oscillator 12 oscillating a frequency twice as much as the medium frequency  $f_b$  and a second oscillator 13 oscillating a frequency twice as much as the interoffice frequency  $f_w$  are provided, respectively, the first oscillation output is fed to a mixer 14 with the local oscillation output  $S_1$ . After the difference frequency  $f_1$ , i. e., the difference angular frequency  $\omega_1$  is formed, the second oscillation output in which the angular frequency obtained by the second oscillator 13 is made to  $2\omega$  is fed to the first mixer 11A.

If the difference angular frequency in the angular frequency obtained by mixing is taken as  $\omega_2$ , and only this frequency component is fed to the second mixer 11B. The composite signal  $S_0$  containing the first broadcast wave  $S_B$  is fed to the second mixer 11B, therefore the sum angular frequency  $\omega_3$  in the frequency-mixed component is used as the second converted composite signal  $S_{OL}$ . The angular frequencies  $\omega_1 - \omega_3$  are as follows, respectively.

$$\omega_1 = 2 \omega_i - \omega_1 \quad \quad \quad )) \quad (1)$$

$$\omega_2 = \omega_1 - 2 )\omega = 2 \omega_i - \omega_1 - 2 )\omega \quad \quad \quad )) \quad (2)$$

$$\omega_3 = \omega_2 + \omega_b = \omega_i - 2 )\omega \quad \quad \quad )) \quad (3)$$

As is evident from Eq. 3, the angular frequency after the conversion of the first broadcast wave  $S_B$  becomes  $(\omega_i - 2 )\omega$  in the second converted composite signal  $S_{OL}$ , and a frequency interval of the first and second converted composite signals becomes  $2 )\omega$ .

This second converted composite signal  $S_{OL}$  is frequency-converted so that the third broadcast wave  $S_C$  exists on the low-pass side and the second broadcast wave  $S_A$  exists on the high-pass side.

In the third frequency converter 10H, the frequency conver-



sion is conducted so that the angular frequency after the conversion of the first broadcast  $S_B$  becomes  $(\omega_i + 2)\omega$ , but the third frequency converter **10H** can be similarly constructed as the second frequency converter **10L** because it can be made by the same procedure as that for obtaining the second converted composite signal  $S_{OL}$ . Accordingly, its description is omitted. Therefore, **15A**, **15B** show the first and the second mixers. The relationships of angular frequencies are as shown below.

$$\omega_4 = \omega_1 + 2\omega = 2\omega_i - \omega_1 + 2\omega \quad \}} \quad (4)$$

$$\omega_5 = \omega_4 + \omega_b = \omega_i + 2\omega \quad \}} \quad (5)$$

Accordingly, as shown in Fig. C, the third converted composite signal  $S_{OH}$  in which the third broadcast wave  $S_c$  is converted on the low-pass side and the second broadcast wave  $S_A$  is converted on the high-pass side is obtained.

Here, frequency components of the converted first to third converted composite signals are examined. Now, the first to the third broadcast wave  $S_A - S_c$  are expressed as follows.

$$S_A(t) = a(1 + f_a(t))\sin \omega_a t \quad \}} \quad (6)$$

$$S_B(t) = b(1 + f_b(t))\sin \omega_b t \quad \}} \quad (7)$$

$$S_c(t) = c(1 + f_c(t))\sin \omega_c t \quad \}} \quad (8)$$

$$f_a(t) - f_c(t): \text{modulation (information) signal}$$
$$S_0(t) = a(1 + f_a(t))\sin \omega_a t + b(1 + f_b(t))\sin \omega_b t + \\ c(1 + f_c(t))\sin \omega_c t \quad \text{)} \quad (9),$$
$$S_{OM}(t) = A \cos(\omega_i + \omega)t + B \cos \omega_i t + C \cos(\omega_i - \omega)t \quad (10)$$

$$\begin{aligned} S_{OL}(t) = & A \cos((\omega_i + 3)\omega)t + \theta_L) \\ & + B \cos((\omega_i - 2)\omega)t + \theta_L) \\ & + C \cos((\omega_i - )\omega)t + \theta_L) \end{aligned} \quad \text{}} \quad (11)$$

$$S_{OH}(t) = A \cos((\omega_i + )\omega)t + \theta_H) \\ + B \cos((\omega_i + 2)\omega)t + \theta_H) \\ + C \cos((\omega_i + 3)\omega)t + \theta_H) \quad \text{}} \quad (12)$$

here,

$$A = a(1 + f_a(t))$$

$$B = b(1 + f_b(t))$$

$$C = c(1 + f_c(t)), \text{ and}$$

$\theta_L$ : the phase difference of carriers of the first broadcast wave  $S_{AT}$  in the first and second converted composite signal  $S_{OM}$ ,  $S_{OL}$  from each other

$\theta_H$ : the phase difference of carriers of the third broadcast wave  $S_{CT}$  in the first and third converted composite signal  $S_{OM}$ ,  $S_{OH}$  from each other

Accordingly, if  $\theta_L = \theta_H = 0$  is taken now and  $S_{OL}$  and  $S_{OH}$  are added to  $S_{OM}$  in reverse phase, only the desired first broadcast wave  $S_A$  is finally received as Fig. 3D because the second and third converted broadcast waves  $S_{AT}$ ,  $S_{CT}$  in the first converted composite signal  $S_{OM}$  are offset each other. Therefore, if an output  $S_o'$  ( $=S_A$ ) of a synthesis circuit 16 is fed to the synchronizer 3 via the medium-frequency amplifier 2, the first broadcast wave  $S_A$  can be AM detected without any adjacent-channel disturbance.

In order to eliminate these broadcast wave  $S_A$ ,  $S_C$ , which should eliminate the disturbance of adjacent channels, the phase difference  $\theta_L$ ,  $\theta_H$  of carriers from each other in the respective

broadcast waves  $S_A$ ,  $S_C$  fed to the synthesis circuit 16 must be zeroed. Therefore, their control circuits are provided in the present invention. Because control circuits 20L, 20H for zeroing the phase differences  $\theta_L$ ,  $\theta_H$ , take the same constitution respectively, the constitution and actions of one control circuit 20L are illustrated in this example.

The control circuit 20L has a bandpass filter 21L and feeds a first converted composite signal  $S_{CM}$  thereto, in this case, only a carrier whose angular frequency becomes  $(\omega_i - \omega)$ , i. e., only the carrier of said first broadcast wave  $S_{AT}$  is extracted, then the second converted composite signal  $S_{OL}$  is  $90^\circ$  phase shifted and fed to a phase comparator 23L constructed, e. g., by a multiplizer to phase compare carriers of the two converted signal  $S_{OL}$ ,  $S_{AT}$  with each other. A DC output obtained by feeding the comparison output to a low-pass filter (not specially illu-

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strated) is fed as its control signal to a phase adjusting circuit 24L provided on a signal transmission path between the oscillator 13 and the first frequency converter 10L.

If such a control loop is constructed, the phase of the interoffice frequency  $f_w$  is continued to be controlled until  $\theta_L = 0$ , therefore the phase difference can be zeroed. Moreover, 22L represents a phase-shifting circuit of  $90^\circ$ .

The phase adjustment in this phase adjusting circuit **24L** is similarly corrected as before so that, e. g., zero crossing points ( $0^\circ$ ,  $180^\circ$  or  $90^\circ$ ,  $270^\circ$  ) of one signal and zero crossing points of the other signal are coincident, namely, their phase difference  $\theta_L$  is zeroed, and the maximum range is  $\forall 90^\circ$ . Accordingly, when the phases of the two signals are reverse and the zero crossing points are not coincident, the phase control is not made so that  $\theta_L = 0$ , and further control actions, i. e., a control action for inverting the phase of one signal is not taken. Therefore, a phase inversion control system is also provided together in the aforesaid control circuit **20L**.

The phase inversion control system has an inverting circuit **25L** and is provided in the latter part of the phase adjusting circuit **24L**. An inversion control signal only utilizes the DC component in an output obtained by comparing the phases of carriers of converted signals  $S_{OL}$ ,  $S_{AT}$  with each other by a comparator (consisting of a multiplizer in this example) **25L**.

It is shown in this example that a carrier phase becomes the reverse phase in case of a positive inversion control signal, therefore the inverting circuit **25L** had better be controlled only in this case.

Accordingly, if the control of phase and polarity is taken by this control circuit **20L**, the second broadcast wave  $S_A$  is not

obtained from the synthesis circuit 16 because the respective carrier phases can be completely coincident.

Constants of the bandpass filter 21H provided in the other control circuit 20H is certainly selected so that the carrier (its angular frequency is  $(\omega_a + )\omega$ ) of the third converted signal  $S_{CT}$  is obtained, if the phase and polarity of carrier are matched in this control circuit 20H, the third broadcast wave  $S_C$  is also offset, accordingly, only the first broadcast wave  $S_A$  tuned by the synthesis circuit 16 is obtained.

As described above, the present invention is characterized by that same broadcast wave which becomes an reverse phase to adjacent channels is obtained by frequency conversion, and they are synthesized to only obtain the broadcast wave taken as channel selection destination, thus the adjacent-channel disturbance can be eliminated, therefore it enables the reception of a desired station without causing signal mixing even if a big electric power station exists in the adjacent channel.

Moreover, the aforesaid actual example is a case of AM receiver, but it is certainly also applicable to an FM receiver.

Brief Description of the Drawings

Fig. 1 is an oscillograph for description of the present invention. Fig. 2 is a system diagram of principal parts showing one example of AM receiver based on the present invention, and Fig. 3 is an oscillograph for description of its actions.

2 medium-frequency amplifier

3 synchronous detector

12, 13 reference oscillators

10M, 10L and 10H first to third frequency converters

20H and 20L control circuits

24H and 24L. phase adjusting circuit

$S_A - S_C$  broadcast waves

$\omega$  interoffice frequency

16 synthesizer

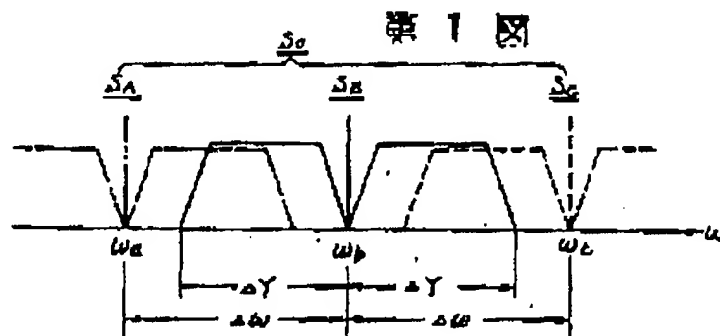


Fig. 1

第 3 图

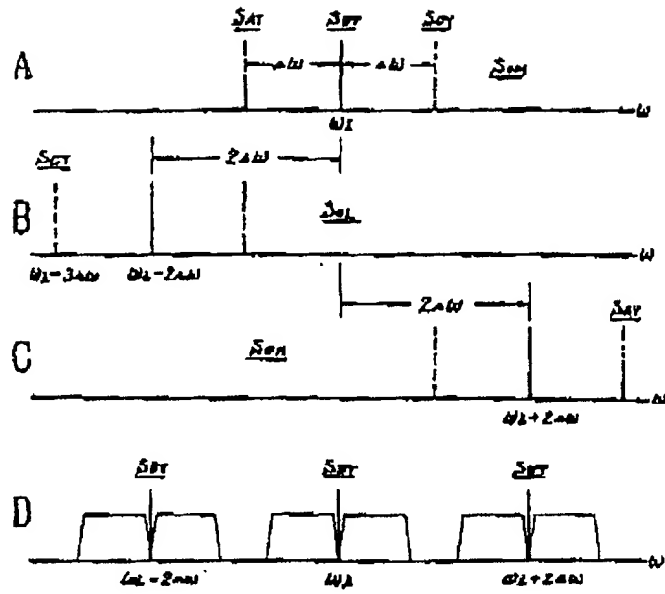


Fig. 3

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第 2 图

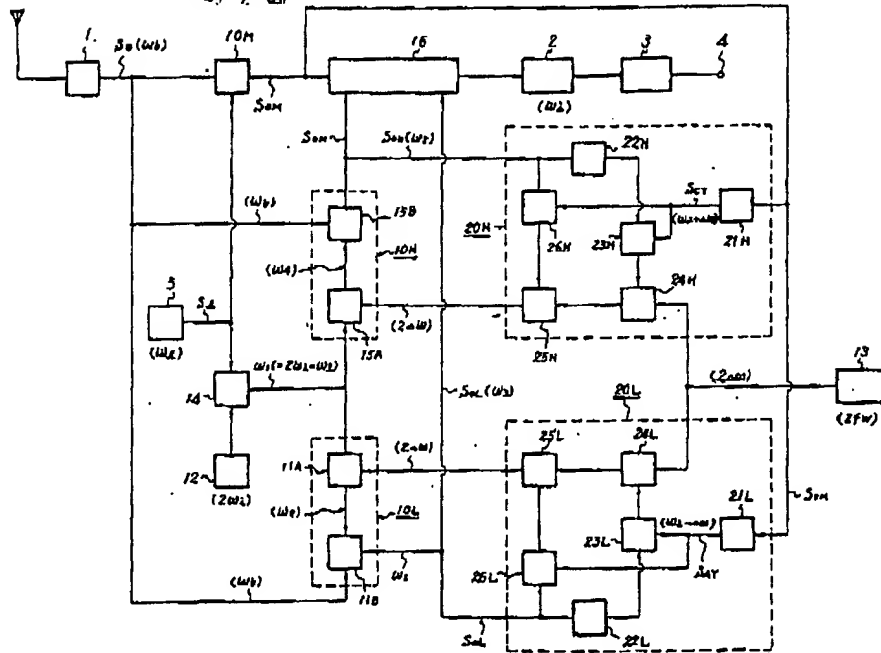


Fig. 2